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THESIS

ON

TERMINALIA ARJUNA

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Thesis on Terminalia Arjuna.

Nat. Order—COMBRETACEÆ.

Distribution.—Lower Bengal, Deccan, N.-W. Provinces.

Description of the Plant.—It is a large tree with pale, smooth and flaky bark; leaves—short-petioled at length, glabrous beneath, oblong or elliptical in old trees, lanceolate in seedlings; flowers—small and spicate; fruit—ovoid, coriaceous drupe with five subequal acute wings which are marked with much ascending striations.

Popular Uses.—The drug is only used by kabirajas and prescribed by them as infusions or ghrita. Its use as a popular remedy is not known. The bark can only be had from the kabirajas or shops dealing with kabiraji medicines; it is sold, in short, half quills from $\frac{1}{8}$ to $\frac{3}{8}$ of an inch thick and several inches long; it has a pinkish colour which can be seen through the thin grey or pale epidermis; the substance of the bark is gritty under the teeth; taste of the bark is agreeably astringent and sweetish; section of the bark shows under the microscope large cells in the medullary rays, and numerous large stone cells of a bright yellow colour bring out a strong contrast; it contains much crystalline matter.

Chemical Composition.—An extract from the bark was prepared by heating 500 grms. of pulverised bark with 2 litres of water until only 500 cc. of the fluid remained; the whole thing was then pressed through a fine muslin, and the fluid part was again filtered through filter when a clear dark-reddish extract was obtained. The extract is sweetish to the taste, reduces Fehling's solution and assumes a dark black colour on treatment with ferric chloride and is acid to litmus. Part of it was treated with benzene in equal parts (being acidulated first with H_2SO_4) and a deposit separated out in the immiscible layer; the immiscible layer was then separated by means of separating funnel and benzene was allowed to evaporate. The residue left after evaporation was reddish-brown in colour and amorphous powder; it was insoluble in dilute Hcl, but partly soluble in alcohol and ether. It does not give any reaction with Iodine, nor does it reduces Fehling's solution, but when heated with dilute Hcl, it reduced Fehling's solution. The alcoholic solution also gave ppt. with Phosphotungstic acid.

Thus we see that the extract when treated with benzene yielded a substance which is partially soluble in alcohol, and does not give any Iodine reaction, reduces Fehling's solution when heated with dilute Hcl and is pptd. by phosphotungstic acid. From these facts we may conclude that the substance yielded from the treatment of the extract with benzene is glucosidal in nature; the glucosidal body was first made soluble in absolute alcohol, which was then evaporated, and a dry brown powdery residue was left; it also gave no reaction with Iodine, reduced Fehling's solution when heated with dilute Hcl.

The extract was then treated with chloroform in the same way, and a gummy substance was obtained which neither gave Orcin reaction nor reduced Fehling's solution even when heated with dilute hydrochloric acid.

The extract was then further treated with absolute alcohol when a reddish-brown-colouring matter was separated out.

It gave no reaction with petroleum ether. Tannic acid was estimated by Allen and Pleteker's method and total tannin (including glucotannic acid, etc.) obtained was 12 per cent.

The bark was then burnt and the ash yielded was 30 per cent., most of which was calcium carbonate, but traces of sodium carbonate and chlorides of the alkali metals was also obtained. Sugar estimated from the original solution was 17 per cent.

Thus we see that the extract from the bark yields-

1. Sugar.
2. Tannin.
3. A colouring matter.
4. A body glucosidal in nature.
5. Carbonates of calcium and sodium and traces of chlorides of alkali metals.

Physiological Experiments.

Experiments on Animals.—A rabbit was injected with 4 drachms of the liquid extract prepared in the above manner in the dorsal lymph sac; it did not develop any poisonous symptom even with three repeated injections in two days. All the change noticed was that it changed colour and appeared paler, the vessels in the ear appeared markedly smaller in calibre, and the paleness of the ears was a marked feature. Another rabbit was given 4 drachms of the extract by the mouth; it neither vomited nor purged, nor was there any abnormal symptom noticed except a change of colour as above noticed with constipation for a whole day; after which period it passed to its original state

On Frog's Heart.—The drug was applied to the heart of a frog whose brain was pithed ; the contractions were recorded by a heart lever on a slowly moving kymograph. The effect is shown in Fig. 1 of Plate at end of paper. It shows the tracing before the application of the drug. Fig. 2 of Plate is the tracing after the application of drug. Here the contractions are distinctly bigger than the original contractions before the application of the drug. Such increase is shared generally during all the periods ; thus the contractions recorded by the *sinus venosus* and the auricles are more marked, but it is in the systolic record that the effect of the drug is so well shown ; the systolic record is stronger and sharper, and the notch is well marked out, while the diastole is distinctly prolonged ; the beats of the heart were slowed, and they were noted to vary from 65 and 70 to between 52 and 60 per minute. These effects were still more marked by repeated application of the drug as will be seen from the records as shown in Fig. 3. In Fig. 4 the sinus, auricular and ventricular contractions are well marked, while the diastolic record show the characteristic prolongation. This action of the drug on the heart is probably nervous, for the application of the drug did not elicit any contraction whatsoever after both the Stannius's ligature indicating complete stimulation of the inhibitory nerve ; had the action been muscular, there would have been at least one contraction after second Stannius's ligature and the application of the drug. This is further illustrated by the following experiment :—A frog whose brain and spinal cord were destroyed had its vagus nerves divided above the origin of the depressor nerve ; immediately the heart became irregular and quicker without demarcating the particular periods as shown in Fig. 5. The drug was now applied, but although the contractions became bigger (may be due to stimulation of the sympathetic) they never regained the same regularity nor the quickness was overcome as shown in Fig. 6. Thus we infer that the drug acts on the heart, slowing its beats, increasing its force, making it regular and increasing its diastole.

But it never acts as a heart poison, stopping its beats altogether, as may be seen from the following experiment :—A frog's heart was taken as usual, and the records made by Verdin's Cardiograph ; first, a normal tracing of the ventricles was taken (Fig. 7) when a very concentrated solution of the drug was applied ; the result was that the heart at once slowed, and the contractions became shorter, but the regularity was maintained all throughout ; the tracing (Fig. 8) shows the action. Then as the action of the drug further proceeded, the contractions became slower and slower, but increased in force—first, three contractions, then a pause ; and finally, two contractions at a time,

and then pause, as shown in the tracing (Fig. 9); but all the while the same regularity was maintained. This state of affairs went on until a single contraction was followed by a pause as in the tracing (Fig. 10), but there was no final stoppage of the heart in any case whatsoever. This effect of the drug on the heart was overcome by the application of normal saline solution, and the heart gradually recovered to its original state as shown in the Fig. 11.

Thus we see that the drug is a cardiac stimulant, increasing the force of contractions and prolonging the diastole; at the same time it slows the heart, but it never acts as a complete cardiac poison.

Experiments on Human Beings.—The stimulant action of the drug on the heart is also shown by the following experiments:—

> Four individuals were given each 4 drachms of the drug for a single dose, and pulse tracings taken before, and 2 hours after the administration of the drug. (See Figs. I to IV and 12 to 19.)

All those tracings show clearly a definite increase in the records caused by the expansion of the artery; the diastolic notch is sharp and well-marked, and the record caused by the retraction of the artery is prolonged after the application of the drug. These effects are more marked specially in those cases that have soft pulses; in the third case, the tracing is abnormally bigger (the pressure remaining the same always); this is probably due to the fellow being an alcoholic, and it is not improbable that he took a dose before the application of the drug, although not to my knowledge. Thus here, too, we see that the pulse tracings are in accord with what we have seen in case of experiments with animals.

Blood Pressure Experiments.—A frog's mesentery was spread out on the stage of a microscope by suitable means and circulation maintained by saline solution. The drug was then applied and the effect watched; the result was that there was a marked contraction of the arterioles, so much so that the calibre of the vessels became less by one-third; the circulation in the capillaries became rather slow but fuller so that the corpuscles appeared as if closely compact; with a stronger dose of the drug circulation ceased in minute capillaries, but there was no complete stasis in bigger vessels although the circulation became considerably slowed; along with this there was considerable diapedesis specially of the red corpuscles evidently caused by the pressure due to constriction of the arterioles. This action continued even when both the brain and the spinal cord were

destroyed ; but discontinued when the ciliac plexus was divided and the vessels immediately dilated.

Thus the drug causes contraction of the peripheral arterioles and increases the diapedesis specially of the red blood corpuscles ; this action, as we have seen, is probably due to the stimulation of the vaso motor nerves.

The drug was applied to human beings in 4 drachm doses of the extract prepared as above, and blood pressure noted by Rivarocci sphygmomanometer after 2 hours. In every case there was increase of blood pressure as shown from the following table :—

BLOOD PRESSURE.

	Before the application of drug.	*After the application of drug.*
Amrit	128	137
Keshoni	109	118
Janki	115	132
Gonaur	117	129

Blood pressure was also recorded in a person by means of Erlanger's sphygmomanometer, little modified by attaching a tambour to the mercurial column, and movements noted by means of a slowly moving kymograph ; this device I was compelled to resort to as the instrument was not properly working, possibly due to a leakage in the original recording tambour of the instrument ; therefore, I am not responsible for the accuracy of the records in this case and the result may be taken as what it is worth for ; only the systolic records were taken for in taking the diastolic records : the turning out of the screw at once brought the mercurial column in the manometer to the same level on both sides. The record was taken at 110 Hg, keeping the pressure constant, and hence it is that no highest systolic record could be obtained. But, however faulty the record may be, it undoubtedly shows a rise in B.P. The drug was also applied to red eyes due to conjunctivitis ; contraction of the scleral arterioles was noticed in all cases, and in one mild case the eye appeared almost cured after the application of the drug twice in course of two hours. In all cases the injection of eyes appeared to be evidently alleviated.

From the foregoing facts we may conclude that the drug in question is a cardiac stimulant increasing the force of systole and slowing the beats of the heart, while at the same time it raises the peripheral blood pressure by contracting peripheral arterioles ; it also helps more or less diapedesis specially of red corpuscles. Its hæmostatic action applied to a bleeding surface the drug quickly prevents hæmorrhage ; this action is due (1) to

the presence of large percentage of tannin; (2) to the presence of a very large amount of calcium salts; (3) and last but not least to its property of contracting peripheral arterioles even when locally applied.

Experiments on Excretory System.—Application of the drug to three persons did not increase the quantity of urine, but a slight increase in the excretion of phosphates and uric acids was noticed, but that increase was merely nominal. The urine was acid all the while and no sugar was detected in urine. Increase in the amount of phosphates and uric acid is probably due to the large percentage of calcium carbonate present in the composition of the drug.

Experiments on other Organs.—On the digestive organs the drug has no action except a little costiveness in repeated and big doses due possibly to the presence of tannin in the drug.

On respiratory and nervous system the drug has no action whatever.

Conclusions :—

(1) The drug (*Terminalia Arjuna*) acts as a cardiac stimulant and tonic, increasing the force of the beats of the heart, but slowing their number, but never completely stopping it. The diastole is more or less prolonged.

(2) The blood pressure is increased due to the contraction of the peripheral arterioles caused by the action of the drug on the vasomotor nerve possibly.

(3) It acts as a powerful hœmostatic ; only drawback for this action is the rise of blood pressure.

(4) It helps diapedesis of red blood corpuscles.

(5) It slightly increases the excretion in the amount of phosphates and uric acid, but the increase is not very material to be taken into practical account.

Other Opinions.—The medicinal property of the drug was known from a very old time, for Chukradutta, one of the oldest Sanskrit authorities on medicine, recommends its use in heart disease, in inflammations and in dropsy originating from heart complications. He gives a preparation of the drug as ghrita, and then the drug if taken is more efficacious.

Dr. Dutt in his Hindoo Materia Medica recommends its use in heart diseases.

Modern eminent kabirajas invariably prescribe it in dropsy from heart disease to be taken as infusion.

In any of the authorities that I have gone through there is no mention of the hœmostatic properties of the drug.

From what has been gone through further comment is unnecessary.

Therapeutic Action.

The foregoing experiments show that the drug is a very valuable remedy in heart diseases, specially where a combined tonic and stimulant action is necessary. Thus in mitral disease, specially in later stages when the heart is feeble and flaccid, blood pressure low and the heart dilated, the drug may be administered with admirable effect. In aortic diseases the drug has one defect, namely, it increases the blood pressure, and the diastole is rather prolonged, but the force of contraction and the manner in which the aortic valves meet together may be utilised in these forms of aortic regurgitation that are caused merely by dilatation of the aorta, or in which the valves, although healthy, do not come in firm opposition, or in which the regurgitation is caused by weakness of the heart.

In exhausting diseases weakening the heart and increasing the frequency of the pulse, the drug is invaluable for it does not exert the poisonous action of digitalis if long continued.

The drug may be used as a good local hœmostatic, but generally its use as a hæmostatic is doubtful on account of the rise of the blood pressure. In inflammations locally and generally it may be used by causing the contraction of the peripheral arterioles, and increasing the diapedesis, and at the same time improving the general circulation, the drug will relieve the inflammatory condition of the part. For this reason Chukradutta recommended it for all sorts of inflammatory conditions, and he goes so far as to say that it heals fractures, etc. For this reason it may be commended in pneumonic inflammations of lung, but directly it has no action on respiratory organs.

We have seen that for local inflammations the drug is very efficacious as in the experiments performed on inflamed eyes. There the inflammation soothed in one day although the case were mild ones. The drug has been suggested to be lethontryptic, but except increasing slight amount of phosphatic and uric acid excretion this action of the drug is doubtful.